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The Extermination of Morning-Glory

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FIG. 1.—Vineyard badly infested with Morning-glory.

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THE EXTERMINATION OF MORNING-GLORY.

By Frederic T. Bioletti.

The wild morning-glory (*Convolvulus arvensis*) is one of the most troublesome weeds in vineyard, orchard, and other cultivated soils. It is a native of Europe, but is well distributed throughout California.

Fig. 2.—Morning-glory (*Convolvulus arvensis*).

It grows in nearly all soils, from light sand to heavy clay, and the better and deeper the soil the more difficult it is to eradicate. Wherever it grows abundantly, it has a most deleterious effect on the crops. This is particularly true of any crop which requires clean cultivation. It may completely destroy young vines and trees, and will stunt and render

unprofitable old vineyards and orchards. It is less harmful to annual crops which mature early, such as hay or grain, as it does not commence to grow vigorously until they are harvested. In alfalfa it does little or no harm, but remains alive ready to infest any susceptible crop which may be planted.

In the worst cases, the growing of trees or hoed crops has sometimes to be abandoned, and, in any case where morning-glory is prevalent, it necessitates an amount of extra cultivation variously estimated at from $5 to $10 per acre.

The weed is a perennial with strong, far-reaching roots. The smallest piece of root is capable of growing and originating a new plant. Ordinary cultivation has no apparent effect except to make it grow more vigorously. Very thorough and frequent cultivation with a good weed-cutter throughout the growing season will keep it down so that there is no appreciable harm to the crop. With vines and small crops, however, this must be supplemented by a considerable amount of hand-hoeing.

Methods of control. Most annual and shallow-rooted weeds will die if cut off an inch or two below the surface of the soil. Many perennial and deep-rooted weeds will make a new growth from the underground portions. In most cases a second or a third cutting below the surface will destroy these. A few will produce a new growth even after repeated cuttings. The morning-glory will produce a new growth continuously every year even if cut off below the surface every time it appears above.

All plant growth originates in a bud. When a weed, therefore, is cut off below the surface, if all buds are removed and if the portions which remain in the ground are incapable of developing dormant or adventitious buds, the plant dies. Every portion of the underground system of the morning-glory is capable of producing adventitious buds with great facility.

Besides buds, new growth requires water and certain food materials of which starch is typical and the principal. The water is obtained from the soil by the roots, and the deep-root system of the mornng-glory keeps it well supplied in this respect. The starch is obtained in the first place by the leaves from the air. The first growth of a bud, however, before mature leaves are produced, is at the expense of a reserve of starch laid up in the stems, or, where these are removed, of that laid up in the roots.

The deeper and more voluminous the root system the greater the reserve of food material available for new growth. It is for this reason that the morning-glory is able to make a new, vigorous growth even after being cut off repeatedly below the surface. The first growth utilizes the starch in the uppermost portions of the roots, which are resupplied by the migration of starch from the lower portions. This

migration is renewed with each cutting until the lower parts of the root system become exhausted of all available food material and die. Finally, if the cuttings are sufficiently frequent and continued long enough, all remaining reserve starch is contained in the uppermost portions of the root system, and one or two more attempts at new growth followed by cuttings will exterminate the plant.

This is not a new theory, but the failure of numerous attempts to exterminate morning-glory by means based on this theory has thrown doubt of its correctness in the minds of many.

There are two causes for these failures. The first is that when the morning-glory appears above the surface it produces normal green leaves very rapidly. These leaves commence the manufacture of starch immediately and quickly replenish the store of reserve material in the upper roots. The draft on the lower roots is thus stopped, and they remain well nourished and healthy. The only way to exhaust the roots, therefore, is to cut off the new growth before it appears above the surface. The second cause is that, owing to the voluminous root system of the morning-glory, the amount of reserve starch is very large. New growth will continue so long as any available starch remains, and it takes a large number of renewals of growth and removals of material by cutting before the whole root system is exhausted.

Roots well supplied with starch and capable of producing new shoots have been found at a depth of 14 feet. In a rich, deep soil at Davis a determination of the weight of roots at different depths was made with the results shown in Table I.

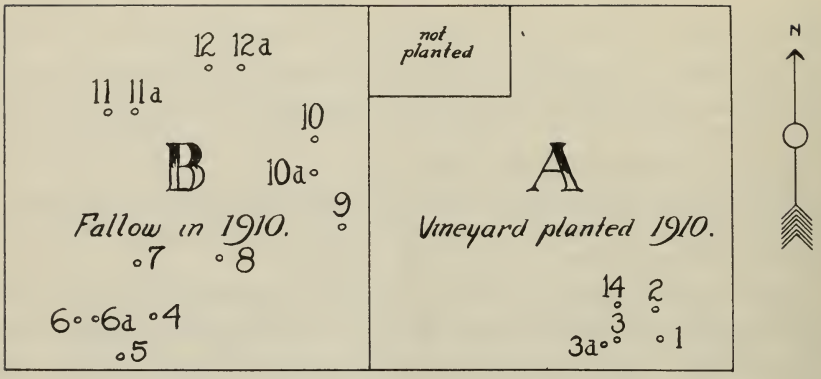
TABLE I.

Weight of Morning-glory Roots in Soil at Various Depths.
Weight in grams to a cubic foot July, 1910.

First foot.	Second foot.	Third foot.	Fourth foot.	Fifth foot.	Sixth foot.	Seventh foot.
7.2	7.3	7.7	9.8	8.4	4.4	2.5

Ths indicates that there is little difference in the volume of roots at different levels down to the sixth foot. From this level down there seems to be a diminution. A micro-chemical examination of the roots showed that they were about equally well supplied with starch at all levels. To exhaust all this mass of food material, extending to a depth of probably more than seven feet and amounting to from $2\frac{1}{2}$ to 5 tons per acre requires a large number of cuttings extending over considerable time.

In order to determine the number of cuttings and the length of time necessary, a test was made on ten acres of bare land at the University Farm at Davis.



Map of location of experiments with Morning-glory.

A. Vineyard, untreated.
B. Fallow land, treated.
The numbers indicate the location of the holes dug to obtain the various samples of roots.

The arrangement of the experiment is shown by the accompanying map which represents 20 acres. The eastern half (A), with the exception of a small portion in the northwest corner, was planted with vines in the spring of 1910. The western half (B), was subsoiled to a depth of about 13 inches and left fallow. In the planted portion, the morning-glory was fairly distributed and was very thick in a few areas, notably near the southeastern corner. In the western 10 acres the morning-glory had formed a continuous thick mat over nearly the whole area, and was particularly dense on the northern half and on a strip along the southern border.

FIG. 3.—Northern half of plot B, showing covering of Morning-glory. The dark shaded portions indicate the area covered with Morning-glory.

The vineyard portion was given ordinary good cultivation with weed-cutters and hoes. The same treatment was given to the western 10 acres up to June 13th. During the growing period before June 13th the morning-glory grew vigorously, and twice appeared above the surface in sufficient quantity to render the whole piece green. From June 13th until June 27th the whole western 10 acres was gone over with a weed-cutter every seven days. It was found that a considerable amount of growth became visible at the end of seven days, and from June 27th to September 13th the weed-cutter was passed over the whole piece every five days. After June 27th, therefore, no morning-glory appeared above the surface.

At the end of the growing season, in order to estimate the effect on the roots of various modes of treatment, weighings were made of the amount of roots in each cubic foot of soil to a depth of 3 or 4 feet in various parts of the field.

In uncultivated soil, where there was a heavy growth of morning-glory, outside the 20 acres, an average of 15.8 grams of roots was found in a cubic foot of soil as shown in Table II.

TABLE II.

Weight of Morning-glory Roots in Uncultivated Soil.

Weight in grams per cubic foot November 14, 1910.

	First foot.	Second foot.	Third foot.	Fourth foot.	Total.	Mean.
Sample 13	15.0	7.5	7.5		30.0	10.00
Sample 15	12.6	23.3	24.2	25.2	85.3	21.3
Sample 16	26.0	12.4	14.2	11.4	64.0	16.0

Average weight of roots in 1 cubic foot of soil equals 15.8 grams.

On the same date weighings were made of the amount of roots in a cubic foot of soil in the southeastern corner of the vineyard, 10 acres, where ordinary good cultivation had been practiced. The results differ little from those in uncultivated soil, the average being 15.1 grams in 1 cubic foot as shown below:

TABLE III.

Weight of Morning-glory Roots in Well Cultivated Soil.

Weight in grams per cubic foot November 14, 1910.

	First foot.	Second foot.	Third foot.	Total.	Mean.
Sample 1	9.4	17.4	16.4	43.3	14.4
Sample 2	6.7	14.7	24.5	45.9	15.3
Sample 3	20.0	29.0	20.5	69.5	23.2
Sample 14	7.2	7.3	7.7	22.2	7.5

Average weight of roots in 1 cubic foot of soil equals 15.1 grams.

The result of ordinary good cultivation, therefore, on the roots in the upper three feet of soil is apparently nil. The injury due to repeated cutting off of new growth is probably counteracted by the better conditions of growth due to cultivation. Micro-chemical examination of the roots showed that in all cases they were well supplied with starch.

Weighings were also made of the amount of roots in a cubic foot of soil in various parts of the 10 acres where weed cutting every five days had been practiced, with results shown in the following table:

TABLE IV.

Weight of Morning-glory Roots in Soil Weed-cut Every Five Days.
Weight in grams per cubic foot November 14, 1910.

	First foot.	Second foot.	Third foot.	Total.	Mean.
Sample 4	5.0	4.6	5.2	14.8	4.9
Sample 5	5.7	3.5	4.5	13.7	4.6
Sample 6	.7	.2	.2	1.1	.4
Sample 7	1.5	3.4	1.0	5.9	2.0
Sample 8	2.5	1.9	1.0	5.4	1.8
Sample 9	5.5	2.5	3.0	11.0	3.7
Sample 10	5.5	9.0	5.0	19.5	6.5
Sample 11	14.0	8.5	6.5	29.0	9.7
Sample 12	18.0	5.0	4.0	27.0	9.0

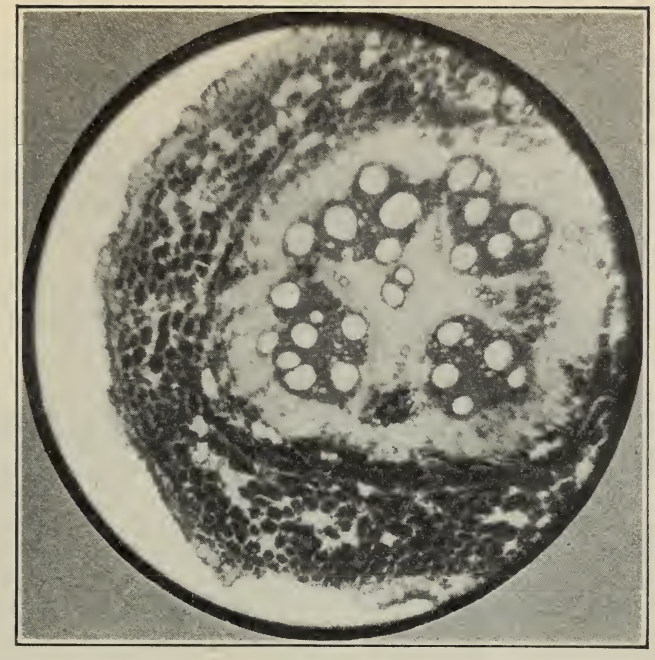
Average weight in 1 cubic foot of soil equals 4.7 grams.

The result of the continuous weed cutting is shown here by a diminution of about 70 per cent in the average weight of roots in a cubic foot of soil. Samples 5, 6, and 7 were taken from a part of the field where the morning-glory had been less dense than in the major portion. If we omit these weighings, the average would be 6.4 grams in a cubic foot, which indicate a diminution of weight of over 60 per cent.

If this decrease in the quantity of roots were the whole effect of the work it would not be worth the expense. Micro-chemical examination of the roots, however, showed that many of them were almost devoid of starch and that, in all, the amount of starch was very small compared with that of roots from the other sources. This is clearly shown by the photo-micrographs on following page.

This almost complete absence of starch indicates an exhaustion of the reserve store of food material. It is by means of this reserve that plants commence their growth in the spring after remaining dormant during the winter. The first spring growth is more or less vigorous in proportion to the amount of reserve food. If this reserve is lacking or too small there will be no growth at all.

That the continuous weed cutting had sufficiently exhausted the reserve food materials of the roots was shown the following year. By the middle of June, 1911, the morning-glory in uncultivated soil was in bloom and growing vigorously. In block A, in spite of vigorous use of cultivator and hoe, it was growing strongly in many places. In



A

B

FIG. 4.—A. Section of Morning-glory root from uncultivated soil. B. Section of Morning-glory root from soil where weed-cutter was used every five days. (Enlarged about 25 diameter.)

NOTE.—Dark contents of cells in bark of A indicating abundance of starch and white contents of cells in bark B indicating complete absence of starch. (Stained with iodine solution.)

block B a careful search of the whole 10 acres revealed less than half a dozen shoots of morning-glory.

Weighings were then made of all the roots which could be found in the first four feet in locations corresponding to those where similar determinations had been made in November, 1910. The following table gives the results:

TABLE V.

Weight of Morning-glory Roots in Treated and Untreated Soil.
Weight in grams per cubic foot June 17, 1911.

	First foot.	Second foot.	Third foot.	Fourth foot.	Total.	Mean.
Untreated—						
Sample 13*a*	11.5	13.0	10.7	5.9	41.1	10.2
Sample 3*a*	9.3	21.0	17.2	9.1	56.6	14.2
Treated—						
Sample 6*a*	.4	.2	.2	----------	.8	.2
Sample 10*a*	.1	.9	1.5	----------	2.5	.8
Sample 11*a*	.1	----------	.6	.2	.9	.2
Sample 12*a*	----------	----------	----------	----------	----------	----------

Sample 13*a* was taken from uncultivated ground near to where sample 13 had been taken in November, 1910. The roots were large and healthy.

Sample 3*a* was taken from nearth the southeast corner of the vineyard close to where sample 3 had been taken in November, 1910. The roots were larger and apparently more vigorous than those of sample 13*a*.

Samples 6*a*, 10*a*, 11*a*, and 12*a* were taken from block B near to where the corresponding samples had been taken the previous November. The weight was insignificant in all cases and with the exception of sample 10*a* the roots were all dead and decayed. Even in sample 10*a* no live roots were found in the upper foot. The few living roots found in the third foot were devoid of starch, and therefore incapable of growing.

Towards the end of July some morning-glory shoots began to appear in several areas of the 10 acres. These areas were in spots where the plow had turned in the preliminary deep plowing of the piece. The ground was left harder in these spots and the surface rougher, so it is probable that the weed-cutter had not worked so perfectly there. Over most of the 10 acres, however, the weed had been completely extirpated.

The 10 acres were gone over carefully and every shoot of morning-glory counted and the numbers compared with the number of shoots growing in an untreated area. The result showed that the weed had been reduced 99.95 per cent—that is, there was only one plant left for every 2,000 present before treatment.

This experiment may be taken as a complete demonstration of the possibility of the practical extermination of morning-glory in one

season by weed cutting repeated with sufficient frequency, where the character of the soil and the condition of the surface are favorable to thorough work.

The main points to be observed are:

1. The weed-cutter must be of such a form that no part of the ground is missed. The form used was a straight knife 4 inches wide and 4 feet 6 inches long. (See figure 5.) This was attached to a riding cultivator drawn by two horses. It was attached perpendicularly to the direction taken by the cultivator. By overlapping about 6 inches on each passage through the piece, it was easy, with steady horses, to avoid missing any

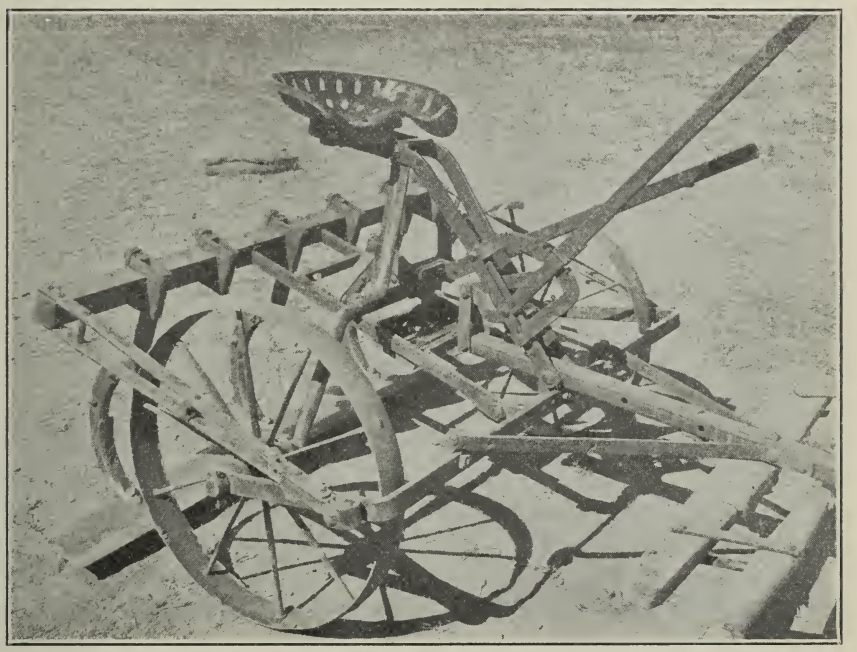


FIG. 5.—Weed-cutter used in the experiments.

spot. On rough land this would be more difficult; where vines, trees, or other crops are growing, impossible.

2. Every weed cutting should take place before any shoots appear above the surface. The smallest growth of green leaves commences to renew the starch, and therefore diminishes the exhaustion of the starch supply of the roots, which is the object of the cutting. Any considerable growth of leaves replenishes the starch supply completely, as illustrated by the effect of the ordinary cultivation of block A.

3. The weed cutting should continue until the coolness of late autumn prevents the growth of the weed. A growth in autumn would probably furnish the partially exhausted roots with sufficient food materials to

preserve them during the winter and to promote a new growth the following spring. How early in the season it is necessary to commence thorough weed cutting was not determined by the experiment. June 1st, at Davis, after the morning-glory had already made a vigorous growth, is evidently not too late.

4. The depth at which the weed knife should be run for the most economical work is another point which was not determined. In the experiment, the depth did not average more than 3 inches. By running the knife deeper—say 5 to 6 inches, it is probable that the time between cuttings could be lengthened and the number of cuttings diminished without any inferiority in the results.

The cost is easily estimated from the above data. From June 1st to November 1st is 153 days, which represents 30 weed cuttings. The 10 acres treated required 2 horses and 1 man one day for each weed cutting, so that the total work required 30 days, which, at $3.00 per day for man and team, represents $90.00, or $9.00 per acre.

Wherever the morning-glory can be exterminated in a piece of land for a cost not exceeding $10.00 per acre, it is undoubtedly economical, and it would, in all such cases, pay to delay the planting of a vineyard or orchard in infested land a year for this purpose. The cost is little more than has to be expended every year in an infested vineyard merely to keep the morning-glory down sufficiently to prevent injury to the vines and without hope of extermination.

Other methods of treatment have been suggested, but all which give promise of successful results depend on the same principle: The promotion of continuous new growth to exhaust the reserve matter of the root system and the removal of this growth before it has an opportunity to replenish these food reserves.

Penning chickens or hogs on an infested spot has been recommended, but it is doubtful if this would be successful unless a comparatively large number of animals were kept continuously on a small patch. Covering the ground with black building paper has also been suggested, and would undoubtedly be effective if the growth of the plants could be prevented from reaching the light between the sheets of paper. In the presence of heavy winds this would be difficult, and in any case probably more expensive than efficient weed cutting.